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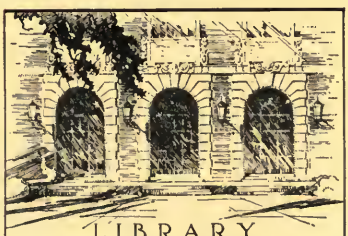

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METEORITE STUDIES II

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CHICAGO, U. S. A.
October 1, 1907.

METEORITE STUDIES II

BY

OLIVER CUMMINGS FARRINGTON.

BATH FURNACE.

Of the three known stones of this fall, one-half the smallest one, weighing 223 grams, came into the possession of the Museum (Mus. No. Me 570). This individual is of irregular disk-like form, of 2½ x 1½ x ¾ inches dimension. A side and front view of it are shown in Plate XXIX. Though its shape indicates that it was a scaling, it was completely encrusted and shows orientation. One of the broad surfaces was plainly the front side, the opposite the rear side. The front side shows lines of flow radiating from an eccentric point. These lines have under the lens the form of ridges of inverted V shape gradually branching and tapering out. These ridges are of shining black glass and rise above a dull-black ground. The interior substance of the meteorite is gray with rusted spots about the metallic grains. It is of sufficiently firm texture to take a good polish. Under the microscope the crust is seen to be relatively thin, .2 - .3 mm. The zones of Tschermak are indicated, but are by no means well marked. For the most part the crust appears as a black, opaque aggregate bordering the edge of the section, with here and there transparent grains of various sizes seen in polarized light to be unaltered olivine. The remainder of the section appears in ordinary light a confused mass of transparent grains considerably iron stained and interspersed with metallic grains of very irregular but usually elongated shapes. Among these troilite is more numerous than nickel-iron. An opaque, black substance also occurs in small quantity connected here and there with the metallic grains. It may be of ferrous or carbonaceous nature. Chondri are but occasionally and imperfectly outlined. In polarized light the chondri can be more readily recognized. They are not numerous, however, the greater part of the section being made up of anhedral grains of various sizes. Chondri where visible are for the most part sharply outlined from the surrounding mass. Those composed of alternate lamellæ of olivine and glass are the most common and next in number are those composed chiefly of fibrous enstatite. Large

chondri composed of porphyritic anhedral olivines or of olivine and enstatite also occur. These olivines frequently reach a length of .2 - .3 mm. and have well-defined prismatic outlines. The interstices between the crystals are usually filled with a turbid glass. The outlines of these chondri as a rule are less well-marked than are those composed of olivine and glass. Most of the chondri have spheroidal outlines, though a few fragmental forms occur. Among the constituents of the general mass, lath-shaped crystals of enstatite .3 - .5 mm. in length, with cleavage parallel to the direction of length are the most conspicuous. These and the enstatite chondri are sufficiently numerous to indicate a large proportion of this mineral in the constitution of the mass. Besides enstatite, grains of olivine of various sizes and outlines are to be seen in considerable quantity.

Plate XXX, from a photograph made by the writer about six months after the fall, shows the place of fall of the 178 lb. mass. The point was the base of the tree in the foreground. The meteorite in falling grazed the tree at the right, leaving a scar the observation of which by a squirrel hunter led to the discovery of the mass. Erection of a pole connecting the scar and the place of fall of the meteorite seemed to the writer to indicate a nearly vertical direction of fall. Miller,* however, estimated the angle to be 77° with the horizon, or 13° from vertical. The large roots of the tree prevented the stone from going deeply into the soil, and it was found resting on them. Considering the weight of the mass and the distance of its fall it is remarkable that it was not shattered by the impact and that the roots on which it fell were not more deeply bruised.

CHUPADEROS.

The two known masses of this meteorite were found, as was stated at an early period, lying only about 800 feet apart. This proximity and the jagged surface to be found on each renders it very probable, as was suggested by Daubree,† if not earlier by others, that the two pieces once constituted a single mass which was torn apart during its fall to the earth. The probable dimensions of this mass were given by Daubree as follows: Length 4.65 m. (16 feet), width 1.50 m. (5 feet) and thickness 0.45 m. (22 inches). The dimensions thus obfained by Daubree were evidently arrived at by assuming a joining of the two masses end to end. Such a joining, however, would not place the torn surfaces together. In order to determine what the form and

* Science, 1903. N. S. Vol. XVIII, p. 244.

† Comptes Rendus, 1889, Vol. CIX, p. 726.

dimensions of the mass would have been if the two parts were joined along the fractured surfaces, the two full-sized models of these masses in possession of the Museum were joined in this way. The resulting form is shown in the accompanying plate. (Plate XXXI.) It is seen to be broad and tabular with irregular outline. Along the line where disruption took place there was an evident constriction. The correspondence between the broken surfaces is such as to leave little doubt that they were once joined. The dimensions of the mass so formed are: Length 12 feet (3.6 meters) and width 7 feet (2.1 meters). The weight of this mass would have totaled about 21 tons (20,881 kgs.). It would be of interest to know which surfaces of the two masses lay uppermost when found, but no record seems to have been made of this point. There is a marked difference in the pittings on the two broad surfaces and they correspond on the two masses when joined. Thus pittings on the side shown in the accompanying plate are deeper and narrower than those on the opposite side. The indications are therefore that the side shown in the accompanying plate was the front side in falling.

As the writer is not aware that any photographs of the two original masses have ever been published, the accompanying cuts (Plates XXXII-XXXIII) from photographs made by him in 1896 are presented. These show the masses as they are installed in the National School of Mines in the City of Mexico. With them, as installed, are placed the Concepcion (Adargas) and Zacatecas meteorites. The large Chupaderos and the Concepcion masses are installed at one side of the entrance of the School of Mines (Plate XXXII) and the smaller Chupaderos and the Zacatecas masses at the other side of the entrance (Plate XXXIII). In Plate XXXIV is shown the Morito (San Gregorio) mass which is likewise installed at the School of Mines, and of which a photograph was made by the writer at the same time. This is a beautifully oriented meteorite and, as will be seen, has been mounted in the position it assumed when falling.

IRON CREEK.

A cast of this meteorite recently received by the Museum (Museum No. Me 763) through the kindness of the Geological Survey of Canada affords an opportunity for the study of some features which have not previously received description. The meteorite is remarkable for its orientation, the characters of front and rear sides being shown very plainly. In perfection of form in this respect it equals the Cabin Creek meteorite, which in general shape it resembles. In previous de-

scriptions of this meteorite* it has merely been stated that the mass was "irregularly triangular and much broader than thick"—and no dimensions have been given.

The form of the Iron Creek meteorite, as seen from its cast, is that of a low cone, 8½ inches (22 cm.) high and 22 inches (56 cm.) in diameter. The outline of the base of the cone is an incomplete circle, an approximately straight contour cutting off one side so that only about three-fourths of the circle is present. The width of the mass in this direction is 17 inches (43 cm.) Were the circle complete the apex of the cone would occupy a position near its center, but with the mass shaped as it is the apex is situated close to the straight side. At one point where the straight side joins the circular outline there was evidently, in the original mass, a prolongation perhaps a few inches in length, which having formed the most convenient part of the meteorite for removal has been sawed off for purposes, doubtless, of analysis and distribution. While the form of the meteorite as a whole is conical, it is also arched, the base being concave and the sides convex. The greatest depth of the concavity of the base is about one and a half inches and occurs opposite the apex. This general concavity is also subdivided by two secondary concave areas, one about seven inches (18 cm.), the other about ten inches (25 cm.) in diameter. These are again subdivided by broad, shallow pits from two to four inches in diameter. The perimetral edge formed by the meeting of the sides and base is irregular in contour and from one to two inches in thickness. The broad, shallow pits of the base, which by their form characterize this as the rear side of the meteorite are, as has been stated, from two to four inches (5-10 cm.) in diameter. Their form is approximately circular although they at times tend to be oval or polygonal. The ridges between the pits are low, rounded and merge into the pits. The pits of the convex surface of the meteorite present considerable contrast to these. They are smaller, rarely exceeding two inches (5 cm.) in diameter, are deeper in proportion to their diameters, more irregular in shape and the ridges between them are higher. They lack uniformity of shape or arrangement. Some are long and narrow, others three-sided, others again more nearly circular. The apex of the cone appears to have been less oxidized than the rest of the mass, indicating that the crust had sprayed off at this point. It presents a smooth surface about two inches (5 cm.) in diameter, convex except for a small, saucer-like depression about ½ inch (1 cm.) in diameter in its center. The base and the sides of the cone meet in a sloping edge except on the side already described as approximately

*1887 Proc. Trans. Roy. Soc. Canada, Vol. IV. p. 97.

straight. Here a broad flat surface is presented, perpendicular to the base of the cone or as if a section had been cut through the cone at one side of the apex and removed. The pittings of this surface resemble furrows and run in general, parallel to the axis of the cone. Some, however, converge from points on the side toward the central point of the base. This is the course which currents of air rushing from the front side backward to the partial vacuum behind might be expected to take. The characters above described make it clear that the convex surface with its deeper, smaller pits was the front side of the meteorite in falling. The characters of the crust cannot be determined from the cast nor are minute drift phenomena, if any occur, to be seen. Brezina, however, states* that the rear side has a bark crust 0.5 to 1 mm. thick. The plate accompanying the present paper (Plate XXXV) shows the characters above described. The adoption by the writer for this meteorite of the name Iron Creek instead of the more usual one of Victoria is on account of information received from Mr. Johnston of the Geological Survey that the small mission station of Victoria, from which the meteorite received that name, is one hundred and fifty miles from the locality where the meteorite was found, and it is no longer known by that name, its present name being Papan. Iron Creek is a well-defined stream only twenty-five miles in length, which takes its name from the fact that the meteorite was found near it. Iron Creek, moreover, is the English translation of the Indian name given to the stream before the white man entered the country. The meteorite was known to the Indians and held in great veneration by them.

LAMPA, CHILE.

Among a number of meteorites obtained by the late Professor Henry A. Ward in Chile in 1905 one was placed by Professor Ward in the hands of the writer for description. The only information given the writer by Professor Ward at that time was that the meteorite had been handed to him by some one at the School of Mines at Santiago. On corresponding with the School of Mines, the Director, Señor A. Orrego Cortes, kindly informed the writer that the meteorite had been found in the Sierra de Chicauma near Lampa. The latitude of the locality is 33° 15′ S. and the longitude 71° W. The height above the sea level is 1000 metres. Señor Cortes also stated that other specimens of the find aggregating 5-6 kilograms in weight had been preserved.

The meteorite is of the stony variety. From the locality it would seem to be a different fall from any yet described. The material pro-

* Wiener Sammlung, 1895, p. 279.

cured by Professor Ward was a single individual about 10 x 15 cm. in size. When received by the writer, however, the mass had been broken in two parts. The smaller of these parts had been sawed in two, and one surface of one polished, while the other part was missing altogether. It is impossible, therefore, to state what the exact original form and weight of the mass was, but it is not probable that the missing part exceeded one pound (453 grams) in weight. The total weight of the parts in hand amounted to 6¼ pounds (2.8 kgs.). Continuation of the contours of the two portions in hand gives a pretty accurate idea of the original form, the space probably occupied by the missing portion being indicated in Plate XXXVI. The original form of the mass was evidently that of a short cylinder about six inches (15 cm.) in diameter and four inches (10 cm.) in height. The surface of one end of the cylinder tends to be convex and that of the other concave. These differences of curvature together with distinctions in crust and pittings show pretty conclusively that one was the front and the other the rear side of the meteorite in falling. On the front and rear surfaces of the meteorite the primary crust is pretty uniformly present. On the sides, however, it appears only at intervals, indicating that during the fall of the meteorite to the earth, or since its arrival, portions have been broken off. How much has been separated in this way it is obviously impossible to determine, but it is quite probable that at one time the mass had a more disk-like shape than at present. The surface of the front side of the meteorite is very smooth and varnish-like. There are no well-marked pits to be seen, the nearest approach to them being three or four shallow, irregular depressions about one inch (2.5 cm.) in diameter. The color of this surface is in general a dull hematite-red, shading to darker about the edges of the meteorite. The smoothness and color give an appearance much as if the surface had been coated with a red varnish. The most remarkable feature of this front surface is a system of cracks or fissures which transverse it. These cracks appear to be quite independent of the contour of the surface. In general they may be said to mark triangular areas, the sides of the triangles being about two inches (5 cm.) in length. In width the fissures vary, but rarely exceed one millimeter. As shown by sections and by pushing a wire into them they penetrate quite deeply into the mass of the meteorite, some being traceable an inch (2.5 cm.) below the surface. Their extension downward is usually in a slanting direction and not perpendicularly. Sections of the meteorite also show cracks running parallel with the surface at a distance of about one-half inch (1 cm.) below it, and others extend inward from the side and rear of the meteorite. The prominent

and visible cracks are, however, all on the front side. That these cracks are due to the necessity of a contracted exterior adapting itself to a larger interior there can be no doubt. Whether, however, their origin is to be ascribed to heating produced by the passage of the meteorite through the atmosphere and consequent contraction upon cooling, or to slower processes of weathering after its fall is not certain. Shrinkage cracks observed upon meteorite crusts at the time of fall are usually of a finer pattern than those here seen and penetrate little below the crust. The rusted character of the interior of this meteorite shows that it has long been exposed to the weather. The Doña Inez meteorite, which was exposed to similar climatic conditions, is described by Howell* as being deeply penetrated by cracks. The writer is therefore inclined to regard the cracks in this meteorite as due to a slow hydration of the interior of the meteorite, such as would be favored by an arid climate. In such a climate, water penetrating into the interior of the meteorite through minute interstices would be held and cause hydration, while from the exterior it would soon dry away. Minute cracks would thus become wedges which would gradually split the meteorite open. The crust of the front side while in general smooth, shows irregular patches and clots of fused matter abundantly distributed over it. These patches are in general darker than the surrounding crust. They are less than ½ millimeter in thickness and a few millimeters broad. They grade, however, into grains which scattered over the surface produce a stippled appearance. Drift phenomena are lacking except, perhaps, for a slight divergent arrangement of grains leading out from one or two of the pits.

The rear side of the meteorite as received showed a whitish coating in many portions. This effervesces and can be removed by acid and is doubtless a carbonate of lime similar to that often observed on meteorites which have been exposed for some length of time in arid regions. When this coating is removed the true crust can be seen. This is in part black and in part red, but always scoriaceous. It is probable that the red color is due wholly to rusting and that the original crust was black. The texture of the crust as seen under the lens is quite uniform and minutely cellular throughout. Minute ridges and hollows and partially opened blebs indicate fusion with the production of gas bubbles. This crust shows a tendency to flake off as a unit when struck with a hammer. It thus has the characters of Brezina's "bark crust." The pittings of this surface are broad, shallow, saucer-shaped and confluent. Their diameters average about one

*Proc. Rochester Acad. Sc., 1890, Vol. 1, p. 93.

inch (2.5 cm.), and as the ridges between them are but slightly elevated they give the surface an undulatory character.

The surfaces intermediate between front and rear show in general transitional crust characters. The crust is more uniform, less scaly and thicker than on the front side and less scoriaceous than on the rear. The edges by which the sides join the front and rear are in general rather sharp but somewhat rounded. One of these side surfaces is a plane, about two square inches (4 cm.) in area, at right angles to the long axis of the meteorite. The clots of fused matter are much thicker and narrower on this face, making it quite rough. Only one other broad side surface occurs. This is concave and has a smooth crust more nearly like that of the front side but thicker. Those surfaces showing no primary crust, but which were original on the meteorite at the time of its finding, are rough from fracture, but a rounding off of the protruding grains has taken place. It is probable that the meteorite broke during its descent to the earth and these surfaces were somewhat glazed over.

The interior of the meteorite presents a compact, homogeneous appearance. In color it is a chocolate to reddish-brown, thickly dotted with metallic grains which show upon a polished surface. It is probable that the present color is largely the result of staining from rust, and that the original color is in no place preserved. The metallic grains are quite minute, few reaching a millimeter in any dimension. They appear uniformly but not very abundantly distributed. To the naked eye no chondritic structure is visible either upon a fractured or polished surface. Under a lens, however, circular spots now dark and now light, but for the most part darker than the prevailing color indicate the presence of chondri. The compact appearance of the meteorite likewise disappears under a lens. The whole surface of a polished mass is then seen to be thickly sprinkled over with minute, irregular holes, which may join or be isolated. These cavities may be in part due to the falling out of grains, in the process of polishing, but as their borders frequently show a coating of limonite, it is probable that many represent an original cellular structure, or are due to weathered-out constituents.

The specific gravity of the meteorite, obtained by weighing a piece of 557 grams, was found to be 3.4005.

Crust sections are of interest in showing a structure different from that usually seen. The crust microscopically shows two well-marked zones. The outer, .1 mm. thick, is opaque and blebby. The inner, .3 mm. thick, has a microlitic structure with occasional rounded crystals of olivine. It is semi-opaque, presenting a gray appearance as

compared with the dark-brown to black of the outer zone. These microlites have an elongated form, averaging about .02 mm. in length and tend to a fibrous structure. Succeeding to this inner zone, while no structural change is apparent as compared with the interior of the meteorite, there is a marked series of cleavage or fracture lines running essentially parallel to the crust. These lines, although irregular and frequently anastomosing, run at intervals of about .05 mm. The zone showing these lines has a width averaging about .2 mm.

As regards the remainder of the section, in ordinary light a field of silicate and metallic grains is presented, with the siliceous constituents exceeding the metallic. There is considerable limonitic staining of the silicates and the metallic grains are for the most part bordered by a dark zone of the same character. Chondri of spheroidal outline occur here and there, but are not abundant. They are rather uniform in size. Their diameters vary from .5 to 1 mm., being generally about .7 mm. In structure they present chiefly the familiar ribbed and porphyritic characters produced by combinations of chrysolite and glass. The general form of the chondri is spherical but many are plainly fragmental. In outline the chondri are rarely sharply separated from the adjoining ground mass, although this is sometimes the case. The ground mass of the meteorite exclusive of the chondri is made up of crystalline fragments varying from minute grains up to individuals .3-.4 mm. in diameter. Many of the larger individuals show crystal outlines which are more or less rounded. High interference colors and strong double refraction show these to be chrysolite for the most part. The larger individuals are traversed by cleavage cracks along which alteration has frequently taken place. This appears in the form of brownish opaque bands which suggest iddingsite traversing the fragments. Aside from these the crystals are free from clouding or inclusions for the most part. One interesting crystal, however, has an outer transparent portion, while the interior shows glass and skeleton growths. The metallic grains consist of nickel-iron and troilite, sometimes singly and sometimes in combination. They have irregular branching forms and seem to fill the interstices between the silicate grains. Their form shows beyond a doubt that they were subsequent in origin to the silicates.

MEJILLONES.

Through an error of the writer in copying Wulfing's classification, the specimen of this meteorite in the Museum collection was designated * as a brecciated hexahedrite. It is in fact an iron-stone meteor-

* Pubs. Field Col. Mus. 1903. Geol. ser. Vol. II, p. 107.

ite and probably a mesosiderite. The error of notation would not have been significant but for the fact that the accompanying description was copied by Cohen* in his account of the brecciated hexahedrites. Under the name of Mejillones two masses of different characters are now to be found in collections, as was early noted by Meunier.† Meunier recommended the name of Pseudomejillones for the iron-stone fall. As such a nomenclature would, however, not be in accordance with present usage it would seem sufficient to designate one as Mejillones, iron, and the other as Mejillones, iron-stone, at least until some further information can be obtained regarding the origin of the masses. It is not impossible, indeed, that they may be parts of the same mass with different structures, as occurs in many pallasites. Of Mejillones, iron, but a small quantity seems to be known. Of the specimens listed by Wulfing‡ under this name, those of Harvard and Ward are iron-stone. The Harvard specimen was obtained by purchase from Ward and Howell§, as was also the specimen in this Museum. Excluding these it leaves the specimen in the Paris collection as perhaps the only well-authenticated one of the Mejillones iron. This specimen according to Meunier was received from Domeyko.

MODOC.

This meteorite has already been made the subject of a brief note‖ and detailed study ¶ by Merrill and a note by the present writer.** Some additional facts obtained by the writer during a visit to the locality in February, 1906, and by study of specimens seem worthy of record. These observations include accounts of the phenomena of fall obtained from various residents of Modoc, also at Tribune, forty miles west of Modoc. The accounts at the latter place show a much shorter interval to have intervened between light and sound than at Modoc. This seems conclusive evidence that the meteor exploded over Tribune and traveled about forty miles before falling. The accounts here given are arranged in the order of the position of the observers going eastward.

Mr. Raines, the station agent at Tribune, was about to lower a curtain at an east window when he saw the meteor at the north going

* Meteoritenkunde, Heft III, p. 233.
† 1893. Revision des fers meteoriques, p. 75.
‡ Die Meteoriten in Sammlungen, p. 230.
§ Huntington, Catalogue of all recorded meteorites, 1887, p. 93.
‖ Science 1906, N. S. XXIII, p. 391.
¶ Am. Jour. Sci. 1906, (4): 21, pp. 356-360.
** Science 1906, N. S. XXIII, p. 582.

eastward. Its appearance was that of a ball of fire, resembling an electric light in color and of the size of a "wash tub." In a short space of time, probably two or three seconds, it exploded, throwing out sparks and then disappeared, leaving no trail behind it. In about 30 seconds three muffled reports and a continuous roar like thunder were heard.

Mr. P. W. Grimes, of Tribune, was sitting with his head down, facing west, when a light like that of an electric light attracted his attention. He saw a ball of fire to the north, traveling east. The light lasted two or three seconds and in about 20 seconds came three muffled reports like those of thunder.

Mr. Willie Baugh was driving south about two miles from Modoc. He saw a light to the west, resembling an electric light, seemingly falling towards him. Then it seemed to describe an upward path and exploded, sparks going in different directions like those of a Roman candle.

Mr. and Mrs. W. E. Curtis, of Modoc, had retired for the night when Mrs. Curtis was awakened by a light so bright that she thought the barn was afire. This light was followed by three reports like thunder and a sound like the wind coming up. She awakened Mr. Curtis, who went to the porch, and then heard sounds like hailstones falling. The fall of each stone was accompanied by slight hissing sounds. Next morning Mr. Curtis found a stone weighing about one pound in his yard, and others later.

Mr. and Mrs. Fred Yost, living only a few rods from Mr. Curtis heard a sound like accentuated thunder, but saw no light nor heard any stones falling. They found several stones about their premises later.

Mr. Schirmeyer, of Modoc, was in doors. He saw a light at an east window and stepped out on the porch to examine it. Two or three explosions like rifle shots followed, also swishing sounds like the dropping of stones. Rumbling sounds then died away to the west for about five minutes.

Mr. Irwin, of Modoc, saw a light below a partially lowered curtain. He called to his wife to see what was going on. She got up for a moment and then retired again; and then came sounds which led them to think that a smashup had occurred on the railroad near by.

Mr. T. D. Marshall was coming up out of his cellar at the time of the fall. His attention was attracted by a bright light in the sky, which was followed by a sound like four beats on a bass drum and others like the swish which accompanies the shooting of a rocket. He then heard stones striking in a number of places about his house. He expected to

be able to find a number of these the next morning, but on searching succeeded in discovering only one.

Mr. McDonald heard sounds like the firing of a machine gun, and a few days later found a small stone about 100 feet from his house.

Mr. J. K. Freed heard sounds like those of a machine gun.

Inhabitants of Scott, about four miles east of the place of fall, generally described the sounds as like those of a wagon traveling over a bridge.

An account of the occurrence published in the local paper, the Scott County Chronicle, Sept. 8, 1905, six days after the fall, was as follows:

"Last Saturday night about 10 o'clock a remarkably bright meteor was seen in the heavens west from this city. It was almost as light as day. The explosion occurred in the vicinity of Modoc and was heard clear across the county. T. D. Marshall had a piece of the meteor in town Wednesday which he found near his house, which is black on the outside and gray on the inside, and is heavily charged with metal indicating silver and gold. It is reported that W. E. Curtis and a man named Pence have found pieces that show that the remnants were scattered over several miles of territory. Mr. Marshall says the commotion in his territory was simply terrifying."

Under Modoc items an account was given in the same paper as follows:

"Last Saturday night about 9 o'clock a meteor passed over this locality. It was followed by a roar that sounded like thunder. It probably bursted, as fragments were heard falling by several persons and T. D. Marshall and W. E. Curtis each found one. The parts found were dark lead color, almost black, and give a metallic sound when struck. They are checked by small cracks indicating an extremely heated condition while passing through the air. They weigh but a few ounces, yet are prized by the finders as they probably represent part of some planet far away, and have traveled for millions of miles through space before finding a resting place on Earth."

The difference in time of these two accounts is accounted for by the fact that in Modoc, Mountain time is used, but in Scott, Central time.

The area over which the meteoric stones were found was one about seven miles by two, the longer distance extending east and west. The region is a rolling prairie, rather thinly inhabited. Much of the area has never been plowed. The native sod, or "buffalo sod," as it is often called, proved comparatively impenetrable to the stones which fell upon it. A slight indentation in the sod showed plainly where a stone weighing 7 pounds, found by the writer, had struck. The ground also

was bare at that point, showing that the grass had been killed. The meteorite did not lie at the point where it had struck, however, but about its own width (four inches) to the south. It had thus evidently bounced southward on striking. Mr. McDonald, of Modoc, informed the writer that the stone which he found had also bounded southward. Mr. Freed, of Modoc, informed the writer that the stone which he found had penetrated the sod about four inches. This was of tabular form and was on edge. It weighed 11 lbs.

The following list shows the individual stones which had been found at the time of the writer's visit and the names of the finders. All of these masses were seen by the writer. The weights are in several cases approximate only. Those that are known accurately are given in grams.

	Weight.	*Finder.*
1.	10¾ lbs. (4,640 grams)	J. K. Freed.
2.	7 lbs. (3,171 grams)	O. C. Farrington.
3.	5 lbs.	F. P. Heller.
4.	2 lbs. 10 oz. (1,170 grams)	F. P. Heller.
5.	1 lb. 15 oz. (879 grams)	F. P. Heller.
6.	1 lb. 6 oz. (624 grams)	John March.
7.	1 lb. 1 oz. (490 grams)	Fred Yost.
8.	14 oz.	—McDonald.
9.	12½ oz.	W. E. Curtis.
10.	10 oz.	T. D. Marshall.
11.	6 oz.	Fred Yost.
12.	6 oz. (170 grams)	Fred Yost.
13.	6 oz.	Mrs. W. E. Curtis.

In addition the find of an individual weighing 1½ lbs. was reported by O. L. Douglass, and of one weighing 2 lbs. by F. P. Heller. Thus a total of at least fifteen stones has been found, having an aggregate weight of about 35 lbs. (16 kgs.).

The distribution of these specimens over the area in falling shows a remarkable gradation in accordance with their size. The stones fell in order of their weight from west to east. This is graphically shown in Plate XXXVII. The two individuals weighing 1 lb. and 2 lbs. each found in the vicinity of the 5 lb. mass are fragments, the remaining portions of which were not found although extended search was made, and the region is exceptionally favorable for searching for meteorites. The smooth buffalo sod has no other stones upon it and the vegetable growth is not sufficient to hide stones of appreciable size. These fragmentary individuals are shown in Plate XL. The complete individuals would probably weigh about 5 lbs. each. Some of the non-crusted surfaces of these show blackening while others are perfectly

fresh. The completely encrusted individuals are of irregular, angular shapes, with angles slightly rounded, as is usual in meteorites. Several, however, show projecting spurs of toothed form which are unusual. No. 10, Plate XXXIX, is especially notable for these. The three views given of this individual show its orientation. The broad surface with rounded shallow pits was the rear side, the opposite the front side. As shown by the side view, the individual is fragmentary.

The individual found by the writer, shown in Plate XXXVIII, has a roughly tetrahedral form with one of the faces of the tetrahedron broken up into three planes. The faces are nearly all slightly concave and show only a few broad pittings. A marked feature of the surface is a whitish deposit occurring on several of the faces. This deposit is more or less streaked in appearance and the direction of the streaks is such that they would meet in a common point if produced. Examined under a lens the deposit is seen to be a fine powder embedded in the interstices of the slaggy crust. It is soluble without effervescence in hydrochloric acid but is so small in quantity that further determination of its nature cannot be made. The simplest explanation of its origin would seem to be to regard it an efflorescence due to weathering, as the meteorite had been exposed five months to the elements when found. The uniformity of direction of the streaks is somewhat difficult to account for on this hypothesis, however. One of the uppermost faces, moreover, is entirely free from the deposit. The deposit lies on what was undoubtedly the forward portion of the meteorite in falling and the radiation of the streaks from a common point suggests that it was made during flight. In either case the phenomenon is new to the writer's experience. The individuals shown in Plate XL were, as already stated, fragments when found, and no adjoining parts have yet been discovered in the vicinity so far as the writer is aware. The encrusted portion of one is seen to be deeply pitted, the pits varying in form and size on the different surfaces. On one surface they are abundant, small and uniformly distributed, on others fewer in number, larger and deeper. The complete individual was evidently of tabular form and about 2 inches (5 cm.) thick. One of the broad surfaces is remarkably flat and shows well-marked divergent lines of flow on the crust. The other individual shown in this plate illustrates the internal veins which occur in some specimens. These veins are evidently only armor faces produced by slipping. They are planoid in character and run in various directions which often intersect. The crust of most of the individuals is dull and coal-black in color, though of reddish tone in some individuals. Crackling of the crust into irregular polygonal areas is a common and characteristic feature,

as shown in several of the plates. The crackle has a mesh-like pattern with meshes in the form of polygons, squares and triangles from ¼ to ½ inch on a side. The appearance is entirely similar to that presented by crackled earthen ware and is doubtless produced by shrinking of the crust in cooling, or expansion of the interior of the meteorite subsequent to the formation of the crust. Another interesting feature seen on the crust of several individuals is that of glazed spots of occasional occurrence. The spots are usually of a greenish color, oval to circular in area, and vary from ¼ to ½ inch in diameter. They doubtless mark the location of chondri of fusible composition.

Under the microscope the crust shows in cross section a thickness of about .5 of a millimeter. The three zones of Tschermak are plainly marked, with widths averaging as follows: Fusion zone .025 mm., absorption zone .1 mm., impregnation zone .4 mm. These zones exhibit the usual characters, the fusion zone being black, opaque and glassy, the absorption zone transparent, and the impregnation zone showing a large proportion of black, opaque matter. The relative widths above given remain fairly constant, although in places the absorption and fusion zones are of about equal width, and again the absorption zone may disappear altogether. The fusion zone is at times also blebby and rough in outline. The interior of the meteorite is megascopically ash-gray in color, in some individuals flecked with rusty spots. The substance is only fairly coherent, and will not polish.

PONCA CREEK.

The writer proposes the name of Ponca Creek for the meteorite usually known as Dakota. The reasons for the change are as follows: The original account by Jackson* states that the fragment which he described was given him by the U. S. Indian agent for the Ponca tribe of Indians, and further that the mass was found on the surface of the ground "in the Dakota Indian territory, ninety miles from any road or dwelling." In the repetition of this statement by foreign authorities a comma came to be inserted after Dakota, so that the locality was known as Dakota, Indian Territory. There is no such locality, however, and Indian Territory is several hundred miles removed from the place where the meteorite was found. Moreover, the original territory of Dakota, within which the meteorite may have been found, is now subdivided into North and South Dakota and neither name would designate the locality in a sufficiently limited way. The reservation of the Ponca Indians, who were a tribe of the Dakotas and from whose agent

*Am. Jour. Sci. (2) 36, pp. 259-261.

the meteorite was obtained by Jackson, was at that time located along Ponca Creek in Nebraska. It seems reasonable to suppose that the meteorite was found in the vicinity of this creek, and the name Ponca Creek has the additional advantage of containing that of the tribe by some member of which the meteorite was probably originally found. For the meaningless name Dakota, therefore, that of Ponca Creek may well, in the opinion of the writer, be substituted.

SALINE.

Some further observations may here be added to the brief account of this meteorite given by the writer in 1902.* The approximate place of find of the meteorite was kindly indicated to the writer by Mr. S. A. Sutton, and this is shown in Plate XLI. No other observations of the fall than those already made by Mr. Sutton and reported by the writer seem to be known. The shape of the meteorite may be described as approximately that of a truncated, four-sided pyramid. The base of the pyramid, shown in Plate XLII, was plainly the rear side of the meteorite in falling. It is the broadest surface of the mass, and has an area of about 144 square inches (900 sq. cm.). In outline it is roughly circular. Mr. Sutton states that this was the surface on which the meteorite rested when found, but this position could have been brought about by an overturn when striking. It was more heavily coated with carbonate of lime when received at the Museum than any of the other surfaces. It is nearly flat, though slightly concave, and shows the broad, shallow pits characteristic of these surfaces of meteorites. On the opposite side of the meteorite a surface having the form of a long and narrow isosceles triangle runs nearly parallel to it and the thickness of the meteorite between the two surfaces ranges from 7 to 8 inches (18 to 20 centimeters). From the parallel surface the meteorite slopes away at angles of 40°, 50°, 60° and 90° approximately. Three of these surfaces are approximately plane, the others are rounded. A view of the meteorite showing this feature is given in Plate XLII. Views of the mass from two other sides were published in the Catalogue of Meteorites of the Museum.† The plane surfaces show practically no pits, the others are more or less irregularly pitted. The more symmetrical of these pits are oval in form, from ½ to ¾ inches in their longest diameter and have a depth about one-fourth as great. All the edges produced by the meeting of different surfaces of the meteorite are rounded.

* Science, N. S. Vol. XVI, pp. 67, 68.

† Pubs. Field Col. Mus. 1903, Geol. ser. Vol. II, Plate XXX.

Except where it has scaled off in small areas the meteorite is covered with a firmly adherent, dull brown-black crust, rough from the protrusion of thickly scattered metallic grains. These grains are darker in color than the rest of the crust, probably from a coating of iron oxide. When this coating is scraped away, however, the bright nickel-white color of the metallic grains is seen. One of the grains showed bright when the meteorite was received, but it may perhaps have become so through handling. It is the largest single grain to be seen. It has a hemispherical form and a diameter of 5 mm. The shapes of the other metallic grains as they protrude are various. Some are elongated, some nearly circular and others form small connecting groups. For the most part the grains are independent of each other, but there are two well-defined groups of them extending in irregular lines and standing out like veins. These are not straight in their course but nearly so. The extent of each is about 6 cm. (2½ inches). One runs from the large grain mentioned above, the other is nearly parallel to it 7 inches (18 cm.) distant.

Besides being broken by the protrusion of the metallic grains, the crust is seamed and fissured by numerous cracks extending in all directions and varying in extent and depth. The largest has a length of 6 inches (15 cm.), and from this to the minutest fissures all gradations occur. The course of most of the cracks is straight towards the interior of the meteorite, but some run so as to tend to scale off. They give the exterior of the meteorite a "baked" look and there can be little doubt that they are the result of differential expansion through heat of the interior as compared with the exterior. Scaling of the crust had occurred at various points when the mass reached the Museum. Many of these scalings must, on account of their freshness, have occurred very shortly before the meteorite struck the earth or from the force of impact. Most of the surfaces thus exposed were covered with an adherent coating of carbonate of lime when the stone was received at the Museum. The lime undoubtedly deposited more readily here on account of the increased capillary attraction afforded by such surfaces. The color of these surfaces was for the most part rusty brown from exposure, but a few were of a greenish-gray color where the carbonate of lime was freshly removed. In addition to these wholly uncrusted surfaces one about three inches square had a very thin black crust, much thinner than the average crust. It is evident that at this point a piece scaled off from the meteorite during its passage through the air and time sufficed for only a partial fusing of the freshly exposed surface.

Internally the substance of the meteorite when freshly broken is

of a greenish-gray color and firmly coherent texture so that it takes a good polish. Enough weathering has taken place, however, to give the interior in large part a dark-brown color. The percentage of metallic grains seen on a polished surface is large, so as to seemingly constitute about one-fourth the mass. The metal is uniformly distributed but the grains vary in size and shape. Some having a diameter of 4-5 mm. are discernible. At times they aggregate into vein-like lines. Both polished and unpolished sections show the interior of the meteorite to be penetrated by a great number of minute fissures arising probably from hydration. Most of them contain carbonate of lime which has doubtless been brought in by infiltrating waters. Such fissures, as well as the metallic "veins" are shown in an illustration published in the Museum Catalogue of Meteorites of 1903.* Under the microscope all the striking characters of the spherical chondrites are presented by the meteorite. Chondri of great variety of size and structure make up the principal mass. For the most part the chondri are spherical in form but some are oval and others of unsymmetrical outline. Besides complete chondri, fragments of chondri are to be seen. As was stated in the writer's first paper on the meteorite, enstatite and olivine either singly or in combination chiefly compose the chondri. Diameters of from .3-.6 mm. are presented as a rule by the enstatite chondri, but one 3 mm. in diameter was seen in one section. Several of the half-glassy chondri show rounded depressions as if made by the pressure of another chondrus. The olivine chondri are both monosomatic and polysomatic, also porphyritic and lamellar. In dimention they vary as widely as do the enstatite chondri and between about shc same limits. The porphyritic individuals of the chondri show, as a rule, well-marked prismatic outlines. Crust sections under the microscope fail to show, except for an outer fusion zone, well marked zones such as are common in the more porous chondrites. The fusion zone is of a dark, nearly opaque, somewhat blebby and glassy nature and has a thickness of about .08 mm. Succeeding this, towards the interior of the meteorite, a zone about .4 mm. in thickness shows scattered opaque impregnations interspersed among unaltered olivine crystals. This zone is not uniform in occurrence, however, and can be seen only at intervals.

WESTON.

In connection with the meteorite fall which occurred at Weston, Connecticut, December 14, 1807, a well-marked distribution of the masses according to weight took place to which attention does not

* Pubs. Field Col. Mus. Geol. ser. Vol. II, Pl. XXXI.

seem to have been called in detail hitherto. In Silliman and Kingsley's account* the fact is noted that stones fell from the meteorite at six different places, over an area 9 to 10 miles in length. It is stated by these authors that these masses fell in a line differing little from the course of the meteor, and probably in the order of the most northerly first and the most southerly last. The relation of the weight of the masses to this order was not traced by these authors, however. This relation as shown by the subsequent account is as follows:—The most northerly fall (near Mr. Burr's) broke into fragments from striking a rock of granite. Its estimated weight was 20-25 pounds. The next fall was at Mr. Prince's, five miles south from Mr. Burr's. This stone weighed 36½ lbs. About half a mile northwest of this, however, one was found weighing 7-10 lbs. and half a mile northeast one weighing 13 lbs. These two masses were doubtless related to the 36 lb. mass. The next mass in a southerly direction was found two miles southeast of Mr. Prince's at Mr. Porter's. This was also broken but is regarded as having weighed from 20 to 25 lbs. and was probably also related to the 36 lb. mass. The largest mass of all fell near Mr. Elijah Seely's, about four miles from Mr. Prince's. The direction of this locality from the others is not stated, but from the context there can be little doubt that it was south. This mass weighed about 200 lbs. The distribution of the masses thus shows a distinct arrangement according to weight and direction. As Bowditch† determined by an independent investigation that the course of the meteor was South 7° West, it is evident that the smaller stones fell first. The distribution of the masses, as above noted, also accords with the statements of several witnesses at the time that the sound of three separate explosions accompanied the passage of the meteor. The smaller masses near Mr. Prince's were evidently thrown off at the time of the second explosion.

* Trans. Amer. Philos. Soc. Phila. Vol. 6, 1809, pp. 323, 325, 335-345.

† Mem. Acad. Arts and Sci. 1815 Vol. 3, pp. 213-236.

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FRONT AND SIDE VIEWS OF SMALL BATH FURNACE METEORITE. X 1¼.

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PLACE OF FALL OF THE 178-LB. BATH FURNACE METEORITE.

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MASS PRODUCED BY JOINING THE TWO INDIVIDUALS OF THE CHUPADEROS METEORITE. X $\frac{1}{24}$.

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CONCEPCION AND CHUPADEROS METEORITES. SCHOOL OF MINES, CITY OF MEXICO.

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REAR, SIDE AND FRONT VIEWS OF CAST OF IRON CREEK METEORITE. x ½.

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FRONT AND REAR VIEWS OF LAMPA METEORITE. X ½.

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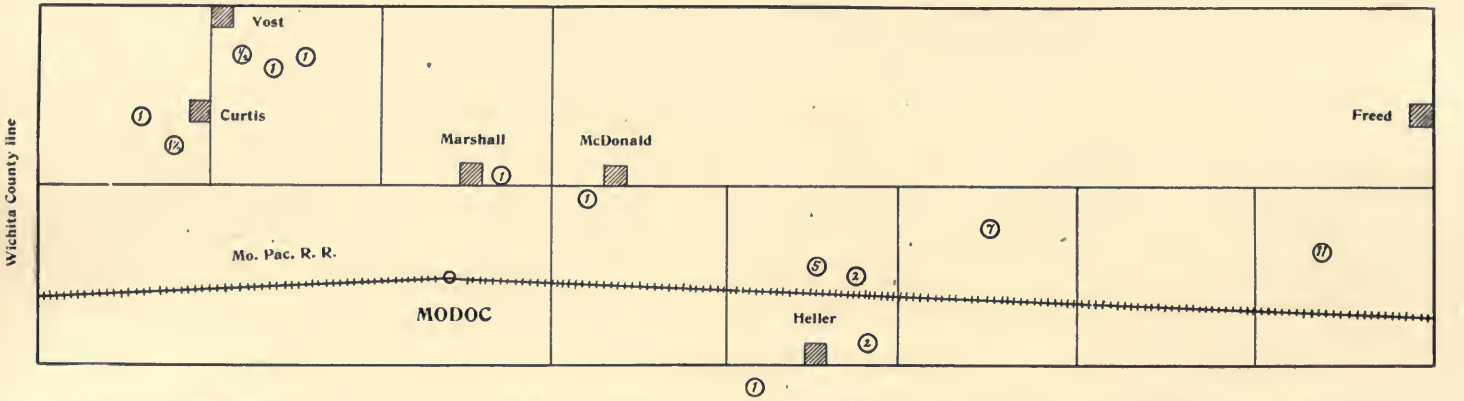

DIAGRAM OF DISTRIBUTION OF INDIVIDUALS OF THE MODOC METEORIC SHOWER. THE FIGURES IN CIRCLES SHOW THE WEIGHT OF THE INDIVIDUALS OR FRAGMENTS. THE SQUARES REPRESENT AREAS OF ONE MILE EACH.

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FRONT AND REAR VIEWS OF 7-LB MODOC METEORITE. X $\frac{15}{16}$.

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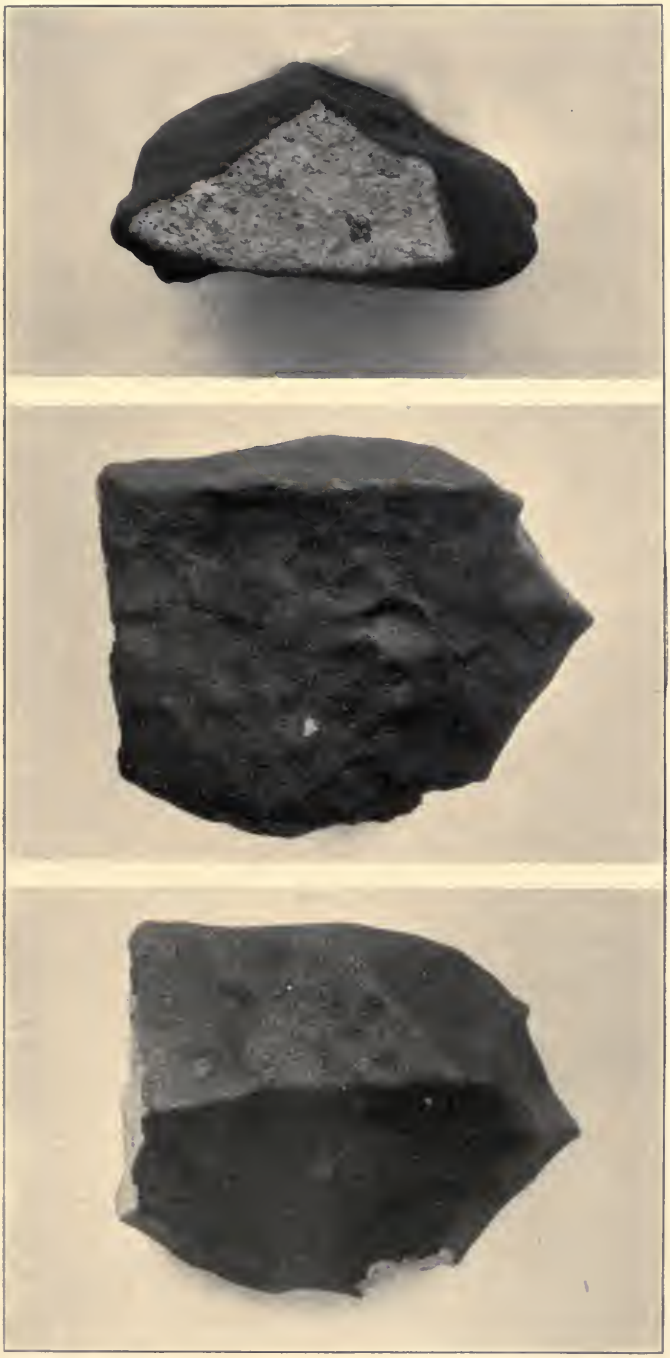

SIDE, REAR AND FRONT VIEWS OF 10-OZ. MODOC METEORITE. X ½.

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FRAGMENTARY INDIVIDUALS OF MODOC METEORITE. NOS. 5 AND 6 OF LIST. X ⅓.

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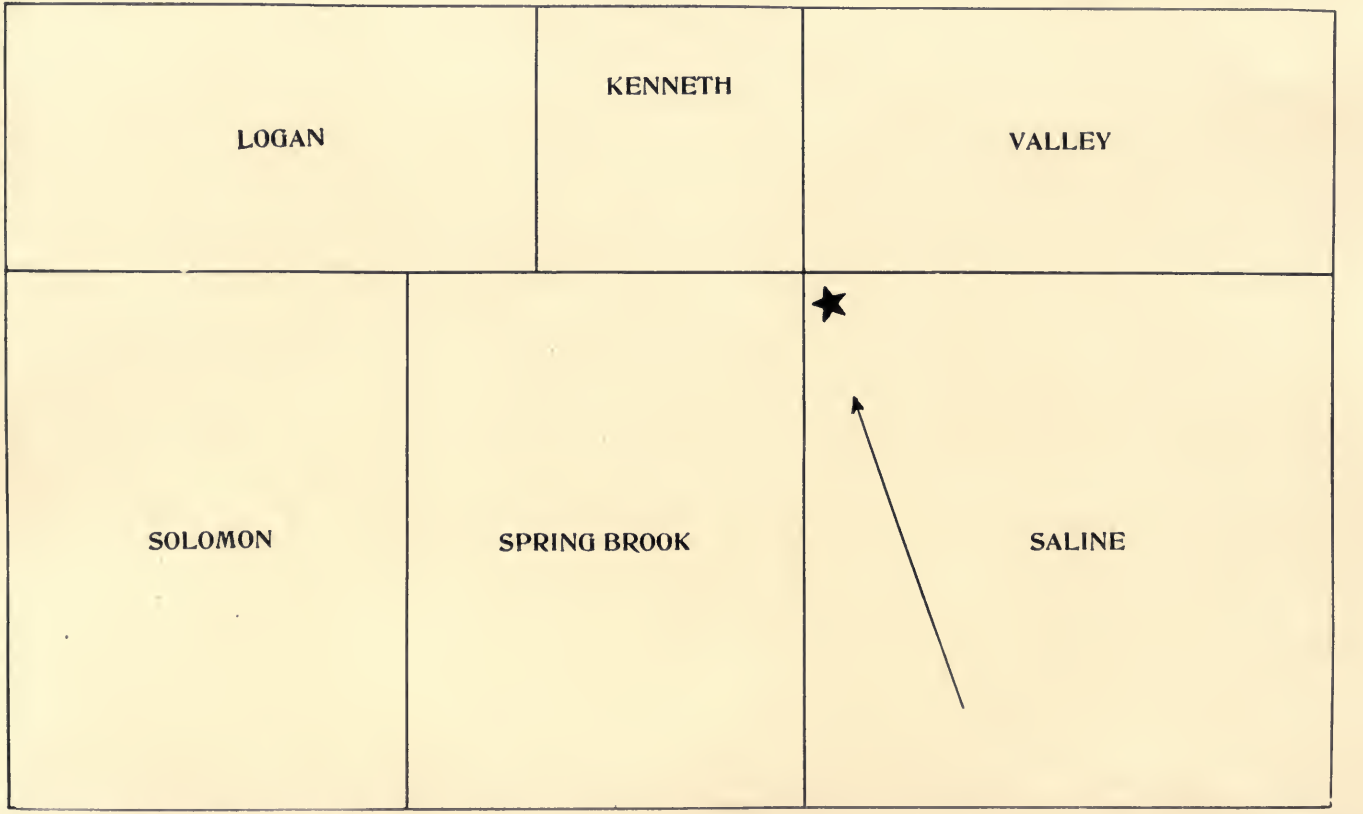

DIAGRAM OF TOWNSHIPS OF THE SOUTHERN PART OF SHERIDAN COUNTY, KANSAS, SHOWING PLACE OF FALL OF SALINE METEORITE AND DIRECTION OF MOVEMENT OF METEOR. SCALE 1 INCH = 4½ MILES.

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FRONT AND REAR VIEWS OF SALINE METEORITE. X ½.

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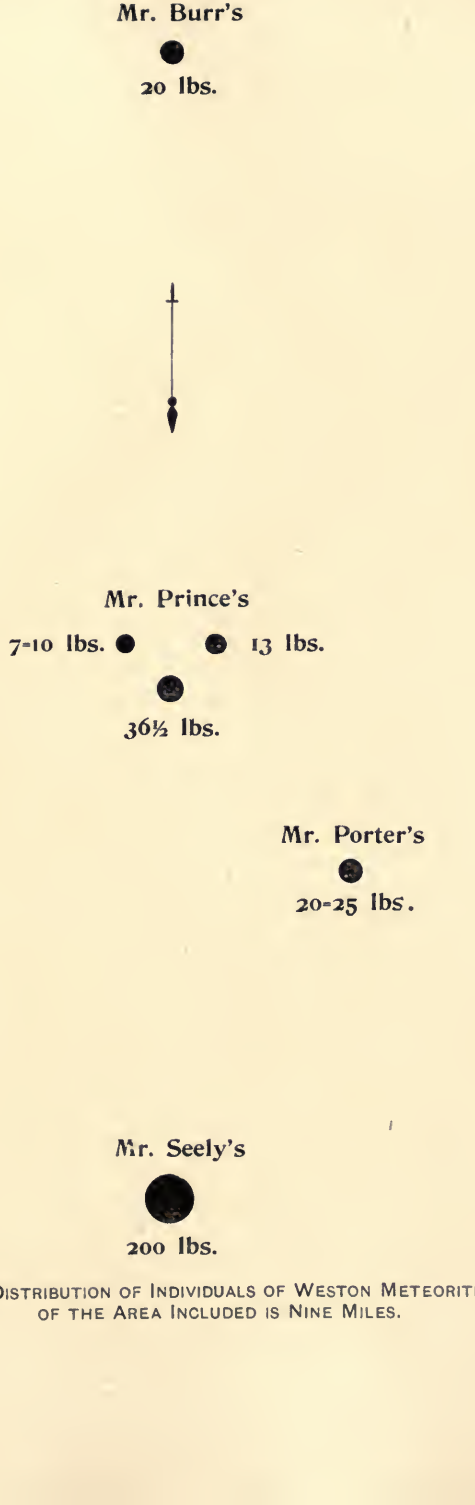

DIAGRAM SHOWING DISTRIBUTION OF INDIVIDUALS OF WESTON METEORITE. THE LENGTH OF THE AREA INCLUDED IS NINE MILES.

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